

Evaluation of Engineering Controls Implemented to Mitigate Godiva Contamination

Summary Report

Compiled by: Joetta Goda

Data Contributed by:
John Bounds, Joetta Goda, Dave Hayes, Kevin McNeil

Burst Info

- 9 bursts performed
- Controls evaluated
 - Top Hat -- passive
 - Air Filtration System -- active
 - Both Controls Combined

	"60"	"150"	"200"
Top Hat and AFS	#2000	#2002	#2003
	24Sep15	27Oct15	28Oct15
Top Hat only	66 C	128 C	265 C
	#2004	#2005	#2006
AFS Only	16Nov15	17Nov15	18Nov15
	62 C	155 C	269 C
	#2007	#2008	#2009
	15Dec15	16Dec15	17Dec15
	53 C	130 C	197 C



Air Samplers, Location and Timing

1 meter from HCA (1 m from Godiva)

- LANL 1 – ON at 30 min following burst, 2.5 cfm
- LANL 2 – continuous, 2.5 cfm
- LANL 3 – ON at 80 min following burst, 2.5 cfm
- RCT – continuous, 2.5 cfm

Hotline (entrance to room)

- LANL 4 – continuous, 2.5 cfm
- RCT – continuous, 2.5 cfm

AFS Exhaust

- RCT – continuous, 2.5 cfm

AFS Filter (at top of AFS, facing Godiva)

- LANL 5 – continuous, 2.5 or 2.0 cfm

Air filters counted LANL count room (alpha spec and gamma spec)

Counted later by NSTec RCTs (gross alpha/beta)

Location of Air Samplers



"Giraffe" air sampler

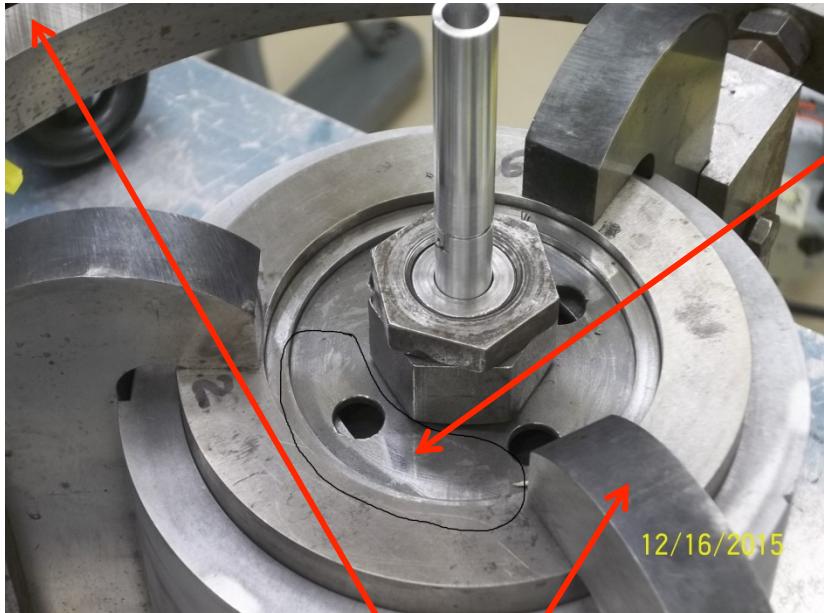
Contamination Survey Results

- Numbers in red are the numbers used for Table 1

Group	Sample ID	Location	THA60	THA150	THA250	TH60	TH150	TH250	A60	A150	A250
			Alpha (dpm)								
HCA	A1	Top Hat (closest to AFS)	90	848	1834	239	243	1399	176000*	5000*	1000*
	A2	Top Hat (away from AFS)	20	347	97	47	510	256	87000*	4000*	70000*
	A4	AFS Inlet Screen	43	340	4868	717	197	14000*	20000*	15000*	15000*
CA/floors	A5	1 foot from assembly, each side (floor)	33	219	200	41	47	47	17	13	357
	A6	1 foot from assembly, each side (floor)	38	38	192	41	232	52	77	13	4
	A7	1 foot from assembly, each side (floor)	31	120	54	49	44	65	15	3	40
	A9	2 m from assembly, each side (floor)	9	541	237	257	184	230	10	18	25
	A10	2 m from assembly, each side (floor)	9	22	17	15	56	211	-1	3	21
	A11	2 m from assembly, each side (floor)	25	42	33	101	115	213	5	2	19
CA/walls	A13	Green strut on south side of room	7	25	15	28	13	154	-3	-2	8
RBA	A15	Room 110 entrance (large doorway)	0	9	12	5	34	31	-3	-3	-1
	A17	Personnel doorway	2	6	4	2	5	22	9	-3	1
	A19	Downstream from AFS exhaust	9	7	1	8	7	4	-1	-2	6
CA/walls	A21	Wall closest to Godiva	-	14	9	16	13	18	2	2	-2
Other	A23	Facility Task Ventilation (screen)	-	-	-	-	-	1940	4905	48	59
											122

*Counted with Electra

Contamination Survey Location Photos



176k dpm (16DEC15): not cleaned during top hat removal



4k-5k dpm (17DEC15): cleaned during top hat removal

Alpha Spectroscopy

- Used to determine amount of HEU on air filters
- Counted 1 day post burst.
- 300 second count. The MDA for the detector setup is 5 dpm.
- Background counts taken before and after each filter.
- Alpha spectroscopy allows for Radon activity to be discriminated.
- 2013 data reanalyzed for consistency

“200” degree Burst Data (dpm)

		12Sep2013	28Oct2015	18Nov2015	17Dec2015
Filter		200°, no controls	265°, Top Hat + AFS	269°, Top Hat	197°, AFS
LANL 1	ON at 30	7395	6	818	14
LANL 2	Continuous	53173	183	18300	329
LANL 3	On at 80	-	<MDA	21	8
LANL 4	CA Boundary	35271	30	5810	24
LANL 5	AFS	-	135	42200	301

“60” degree Burst Data (dpm)

		10Sep2013	24Sep2015	16Nov2015	15Dec2015
Filter		60°, no controls	66°, Top Hat + AFS	62°, Top Hat	53°, AFS
LANL 1	ON at 30	7	<MDA	7	13
LANL 2	Continuous	312	<MDA	275	19
LANL 3	On at 80	-	<MDA	11	<MDA
LANL 4	CA Boundary	230	<MDA	250	<MDA
LANL 5	AFS	-	-	2480	5 (MDA)

“150” degree Burst Data (dpm)

		11Sep2013	27Oct2015	17Nov2015	16Dec2015
Filter		108°, no controls	128°, Top Hat + AFS	155°, Top Hat	130°, AFS
LANL 1	ON at 30	-	<MDA	160	<MDA
LANL 2	Continuous	6040	21	3860	40
LANL 3	On at 80	-	<MDA	13	5
LANL 4	CA Boundary	4087	<MDA	1860	8
LANL 5	AFS	-	13	66700	46

Gamma Spectroscopy

- To determine fission products on air filters
- Counted 1 day post burst
- 30 minute gamma spectra
- Identifies peaks of fission fragments
- Old data reanalyzed for consistency

197 degree Burst Data (Bq at Time of Measurement) by Location

	ON at 30	Continuous	ON at 80	CA Boundary	AFS
Isotope	LANL 1	LANL 2	LANL 3	LANL 4	LANL 5
Mo-99	<MDA	5.2	<MDA	1.5	4.5
Ce-143	<MDA	13.7	<MDA	1.7	8.6
I-133	<MDA	9.0	<MDA	1.4	6.4
Nb/Zr-97	<MDA	15.0	<MDA	2.0	11.4
Sr-91	4.4	132	<MDA	156	126

Gamma Spectroscopy Comparison by Control

- Comparison of Data for “LANL 2” Continuous Air Filter

“200” degree Burst Data (Bq at Time of Measurement) by Control

	12Sep2013	28Oct2015	18Nov2015	17Dec2015
Isotope	200°, no controls	265°, Top Hat + AFS	269°, Top Hat	197°, AFS
Mo-99	409	3.7	188	5.2
Ce-143	471	7	253	13.7
I-133	488	4.1	318	9.0
Nb/Zr-97	913	9	510	15.0
Sr-91	2240	28	1250	132

“60” degree Burst Data (Bq at Time of Measurement) by Control

	10Sep2013	24Sep2015	16Nov2015	15Dec2015
Isotope	60°, no controls	66°, Top Hat + AFS	62°, Top Hat	53°, AFS
Mo-99	63	0.2	30	1.6
Ce-143	78	0.8	40	3.9
I-133	35	<MDA	53	<MDA
Nb/Zr-97	160	0.8	91	2.1
Sr-91	300	2	153	16

“150” degree Burst Data (Bq at Time of Measurement) by Control

	11Sep2013	27Oct2015	17Nov2015	16Dec15
Isotope	108°, no controls	128°, Top Hat + AFS	155°, Top Hat	130°, AFS
Mo-99	142	0.9	89	1.9
Ce-143	164	3	116	6.2
I-133	79	0.9	146	2.7
Nb/Zr-97	330	3.2	240	4.6
Sr-91	675	8	540	64

HEU and Fission Product Contribution to Total Airborne Dose

Rates

- As burst size increases, the contribution from airborne HEU increases faster than the contribution from fission products.

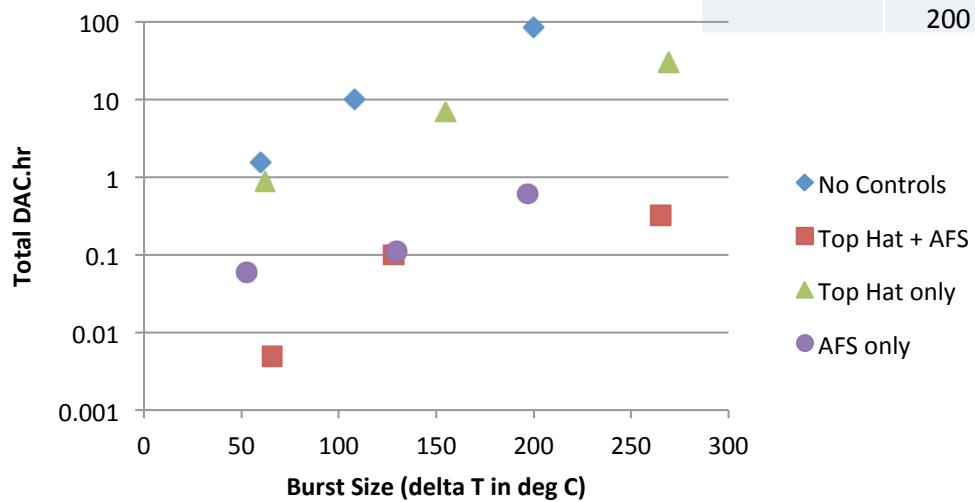


Table 1: Engineering Control Effectiveness Determination Table

Control	Nominal Burst delT	1 meter air sampling station		Highest Swipe in each Area [dpm/100cm^2]								Control Effective? Y/N
		DAC-h	<10 DAC-h? Y/N	HCA	< 100,000? Y/N	CA Floor	< 5,000? Y/N	CA Walls/ Cables	< 2,000? Y/N	RBA	< 200? Y/N	
NONE	60	1.5	Y	-		-		-		-		
	150	10	Y	-		-		-		-		
	>200	85 12.4	N*	-		-		-		-		
Top Hat and AFS	60	<0.005	Y	90 α/ 507 β	Y	43 α/ 509 β	Y	7 α/ 25 β	Y	2 α/ 10 β	Y	Y
	150	<0.1	Y	848 α/ 2363 β	Y	541 α/ 79 β	Y	25 α/ 11 β	Y	9 α/ 6 β	Y	Y
	>200	0.32	Y	4868 α/ 28377 β	Y	237 α/ 86 β	Y	15 α/ 36 β	Y	12 α/ 24 β	Y	Y
Top Hat	60	0.87	Y	717 α/ 256 β	Y	257 α/ 23 β	Y	28 α/ 7 β	Y	5 α/ 3β	Y	Y
	150	7.0	Y	510 α/ 80 β	Y	231 α/ 23 β	Y	28 α/ 7 β	Y	5 α/ 3β	Y	Y
	>200	30.5	N*	1399 α/ 3277 β	Y	230 α/ 235 β	Y	154 α/ 603 β	Y	31 α/ 115 β	Y	Y
		1.4	Y									
AFS	60	0.06 0.02	Y	176,000 α	N**	77 α/ 40 β	Y	2 α/ 7 β	Y	9 α/ 11 β	Y	Y
	150	0.11 <0.01	Y	15,000 α	Y	18 α/ 3 β	Y	2 α/ 3 β	Y	-2 α/ 4 β	Y	Y
	>200	0.6 0.02	Y	70,000 α	Y	357 α/ 1052 β	Y	8 α/ 2 β	Y	6 α/ 11 β	Y	Y

*Two DAC-h values are entered: One for the continuous air sample and one for the air sample started 30 minutes post burst. The values indicate a rapidly decreasing airborne radioactivity environment. DAC-h values are the combination of airborne fission products and HEU.

**The 176,000 alpha resulted from a swipe taken on top of the Godiva core that was not cleaned during removal of the top hat. As such, it represents the accumulation of at least 8 bursts. The evaluation data review concluded that this was an anomalous result, as supported by subsequent surveys.

This work is supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.